

Stroboscopic Interferometer for Measuring Mirror Vibrations

Interferometric snapshots are taken at intervals over a cycle for each vibrational mode.

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Stroboscopic interferometry is a technique for measuring the modes of vibration of mirrors that are lightweight and, therefore, unavoidably flexible. The technique was conceived especially for modal characterization of lightweight focusing mirror segments to be deployed in outer space; however, the technique can be applied to lightweight mirrors designed for use on Earth as well as the modal investigation of other optical and mechanical structures.

To determine the modal structure of vibration of a mirror, it is necessary to excite the mirror by applying a force that varies periodically with time at a controllable frequency. The excitation can utilize sinusoidal, square, triangular, or even asynchronous waveforms. Because vibrational modes occur at specific resonant frequencies, it is necessary to perform synchronous measurements and sweep the frequency to locate the significant resonant modes. For a given mode it is possible to step the phase of data acquisition in order to capture the modal behavior over a single cycle of the resonant frequency.

In order to measure interferometrically the vibrational response of the mirror at a given frequency, an interfer-

ometer must be suitably aligned with the mirror and adjustably phase-locked with the excitation signal. As in conventional stroboscopic photography, the basic idea in stroboscopic interferometry is to capture an image of the shape of a moving object (in this case, the vibrating mirror) at a specified instant of time in the vibration cycle. Adjusting the phase difference over a full cycle causes the interference fringes to vary over the full range of motion for the mode at the excitation frequency. The interference-fringe pattern is recorded as a function of the phase difference, and, from the resulting data, the surface shape of the mirror for the given mode is extracted.

In addition to the interferometer and the mirror to be tested, the equipment needed for stroboscopic interferometry includes an arbitrary-function generator (that is, a signal generator), an oscilloscope, a trigger filter, and an advanced charge-coupled-device (CCD) camera. The optical components are positioned to form a pupil image of the mirror under test on the CCD chip, so that the interference pattern representative of the instantaneous mirror shape is imaged on the CCD chip.

The mirror is acoustically excited into vibration by use of a loudspeaker or other suitable mechanical transducer. The signal generator provides the sinusoidal signal for driving the loudspeaker. The signal-generator output is also processed through phase-locking and phase-shifting circuitry to generate an adjustably-phase-shifted trigger signal, locked in phase to the excitation signal, for triggering the CCD camera to capture an image at the desired instant during the vibration cycle.

Advanced single-frame phase-shifting interferometers can be used for data acquisition to produce high spatial resolution measurements and "phase movies" of the vibrating surface. The maximum resonant frequency measurable is determined by the camera exposure time for synchronous measurements and camera frame rate for asynchronous excitation. Synchronous measurements at rates up to 100 kHz are possible with this technique.

This work was done by H. Philip Stahl of Marshall Space Flight Center and Ted Rogers of the University of Alabama in Huntsville. Further information is contained in a TSP (see page 1). MFS-32057